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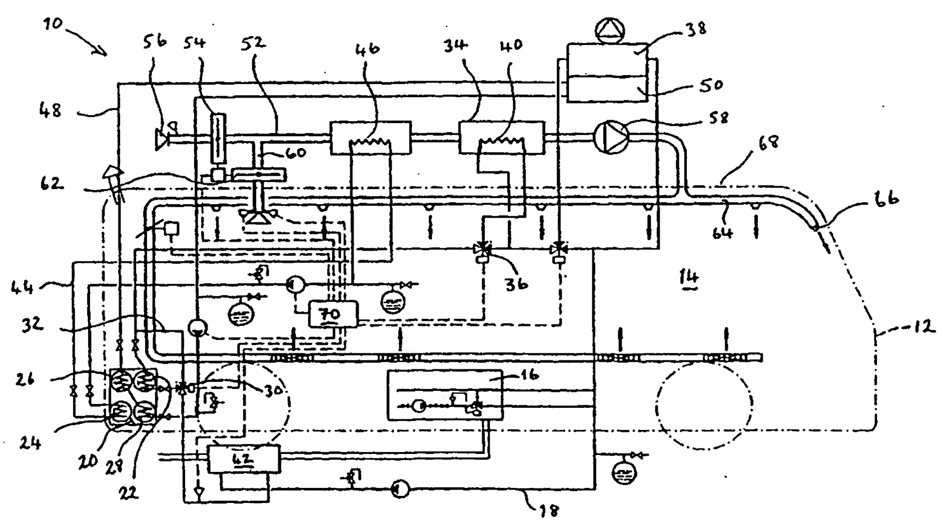
(54) Title: THERMAL SYSTEM FOR A VEHICLE



(57) Abstract

A thermal system (10) for a vehicle (12), particularly a bus. The vehicle has a passenger compartment (14) and an internal-combustion engine (16) cooled by an engine cooling fluid flowing through a closed engine cooling circuit (18). The system includes a refrigerating absorption unit (20) having a generator (22), an evaporator (24), an absorber (26) and a condenser (28). To provide improved efficiency, the system further includes means for supplying the generator (22) of said refrigerating absorption unit (20) with heat energy from the engine cooling fluid; means (42) for adding energy to the engine cooling fluid during its passage from the internal-combustion engine (16) to the refrigerating absorption unit (20), and a first heat exchanger (38) provided downstream of the refrigerating absorption unit (20) for dissipating excess energy in the engine cooling fluid before the engine cooling fluid is returned to the internal-combustion engine (16).

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TITLE: Thermal system for a vehicle

TECHNICAL FIELD:

The present invention relates to a thermal system for a vehicle, particularly a bus, according to the preamble of claim 1.

The invention further relates to a method for providing climatic conditions in a passenger compartment of a vehicle, preferably a bus, according to the preamble of claim 9.

BACKGROUND OF THE INVENTION:

The demands placed on the public transport vehicle are becoming increasingly complex. These demands include increased climatic comfort for the passengers, improved fuel efficiency of the vehicle and reduced operator's costs in terms of both purchase costs and running costs. In addition, increasing awareness of global environmental issues and government legislation are forcing manufactures to use more environmentally-friendly materials in the construction of vehicles.

Generally, the climate in the passenger compartment of a bus is typically provided by utilizing separate devices for cooling and heating, with both devices drawing power from the vehicle's engine to perform their respective functions.

The most common form of heating circuit in use today is based on radiators or convectors mounted at the base of the passenger compartment walls and being connected by a network of copper piping to the engine cooling system. Such a circuit is often equipped with one or more circulation pumps and a series of valves. It is common practice to divide the heating circuit into two or three parts; a passenger circuit, a driver circuit and a defroster circuit. Due to more efficient engine technology, the heat

energy available in the engine cooling system is often insufficient to meet the passenger compartment heating requirements. For this reason, certain systems are provided with for example diesel-fired auxiliary heaters to provide more energy to the fluid in the cooling system.

The above-mentioned type of heating circuit is associated with several drawbacks. For example, water-based circuits are prone to leakage and the requisite pipework requires relatively long and therefore expensive installation processes and is relatively heavy. In addition, auxiliary heaters not only consume fuel, they are also heavy and cumbersome. Furthermore, the response time of water-based circuits is slow. This is a particular disadvantage in busses due to the fact that large and rapid changes in the temperature of the air in the passenger compartment often occur when the doors to the compartment are opened to allow the embarkation and disembarkation of passengers.

Cooling of the passenger compartment is generally achieved using an air-conditioning system. Such systems are typically standard format machines with compressors, evaporators and radiator packs based on CFC/HCFC "Freon" type or R134 type coolants. In some cases, CO_2 or other media are used to reduce possible environmental and safety risks in handling and maintenance procedures. It is common for modern air-conditioning units to have a so-called re-heat function in which, under periods of operation, cold air coming from the evaporator of the unit is reheated slightly prior to reintroduction to the passenger compartment. The available power of the reheat heat exchanger varies commercially, but can easily be in the range of 30 to 40 kW. The reheat heat exchanger is also dependent upon energy supplied by the engine cooling circuit. The power of the cooling condenser/heat exchanger also varies, though it is dependent upon the power of its

compressor. As described, for example, in US-A-4 888 959, the compressor is commonly driven by the vehicle's engine, something which reduces power to the drive train and increases fuel consumption.

In order to at least partially overcome some of the drawbacks associated with compressor-driven air-conditioning units, so-called refrigerating absorption systems have been developed which utilize the exhaust gas of the vehicle engine as a source of heat. In this respect, EP-A-0 350 764 and DE-C-41 42 314 can be mentioned by way of example.

Despite the developments which have taken place in air-conditioning units, a need still exists for a climate system which is more efficiently integrated in a thermal system of the vehicle. In other words, the present applicants have recognized that significant cost savings can be enjoyed and passenger comfort can be increased by designing a thermal system for a vehicle in which the cooling needs of the vehicle's engine can be satisfied at the same time that waste heat from the engine is used to power a climate system for the passenger compartment.

SUMMARY OF THE INVENTION:

It is therefore an object of the present invention to provide a thermal system for a vehicle which overcomes the drawbacks associated with vehicles having a liquid-cooled engine powering conventional passenger compartment heating and cooling systems.

This object is achieved by the thermal system as claimed in claim 1.

It is a further object of the present invention to provide a method of climatising a passenger compartment of a

vehicle, which method overcomes drawbacks associated with conventional heating and cooling systems.

This object is achieved by the method as claimed in claim 9.

Preferred embodiments of the invention are detailed in the respective dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will be described in the following in greater detail by way of example only and with reference to the embodiment shown in Fig. 1 which is a schematic representation of a thermal system according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS:

In the drawing, reference numeral 10 generally denotes a thermal system incorporated in a vehicle 12. Although the system will be described in the following in connection with a bus, it is to be understood that the system may also be applied to any vehicle which employs a fluid-cooled internal-combustion engine. The bus 12 is provided with a passenger compartment 14 and an internal-combustion engine 16, typically a diesel engine. The engine is cooled by an engine cooling fluid, for example water containing an antifreeze agent, flowing through a closed engine cooling circuit 18.

The thermal system 10 includes a refrigerating absorption unit 20 having a generator 22. The unit further comprises an evaporator 24, an absorber 26 and a condenser 28. In a manner which will be described later, the refrigerating absorption unit serves to cool air which is to be admitted into the passenger compartment 14. The closed engine cooling circuit 18 is selectively connected to the

generator 22 of the refrigerating absorption unit by first valve means 30. Thus, the first valve means 30 may be controlled to either allow the engine cooling fluid to bypass the generator 22 via a bypass conduit 32 or allow a variable amount of the engine cooling fluid to flow through the generator. When the first valve means 30 is in a position which allows engine cooling fluid to flow through the generator 22, the refrigerating absorption unit 20 will be supplied with heat energy from the engine cooling fluid.

Downstream of the refrigerating absorption unit 20, the closed engine cooling circuit 18 is selectively connected to a vehicle heating unit 34 by second valve means 36. A first heat exchanger 38 is provided in the closed engine cooling circuit downstream of the heating unit 34 to dissipate any excess energy in the engine cooling fluid before the fluid is returned to the internal-combustion engine 16. The vehicle heating unit 34 advantageously comprises a second heat exchanger 40 for heating air for distribution in the passenger compartment 14.

A typical bus has a heating demand of 30-35 kW to maintain suitable climate conditions on board, depending on ambient conditions, required fresh air flows and the physical characteristics of the bus. Modern diesel engines used in trucks and busses, however, have a heat energy output via the engine cooling fluid of only 15-20 kW. In order to rectify this power deficit, the thermal system of the present invention is provided with means 42 for adding energy to the engine cooling fluid during its passage from the engine 16 to the refrigerating absorption unit 20. Although such means could conceivably be, for example, a diesel-fired heat source, a gas-fired heat source or an electrical heater, in a preferred embodiment of the present invention the means 42 is an exhaust gas heat recovery unit. An eminently suitable unit is the subject of Swedish

patent application no. 9603740-3, the contents of which are hereby incorporated by reference. Such an exhaust gas heat recovery unit 42 can be dimensioned to provide anywhere from 15 to 45 kW without great difficulty.

Thus, in a pure heating mode, the engine cooling fluid flows from the engine 16 to the exhaust gas heat recovery unit 42. Thereafter, the cooling fluid flows to the second heat exchanger 40 in the vehicle heating unit 34 to heat incoming air. Once the engine cooling fluid has passed through the vehicle heating unit, any excess energy in the fluid is removed by passage through the first heat exchanger 38 before being returned to the engine 16.

In accordance with a further aspect of the present invention, the heat energy in the engine cooling fluid can be used to power cooling means which are used to cool air for distribution in the passenger compartment. Thus, the energy made available in the generator 22 of the refrigerating absorption unit 20 is utilized for this purpose. The cooling capacity needed for a bus installation is typically about 25 kW with a cooling medium temperature of about 10 degrees C. Given that the refrigerating absorption unit 22 has a coefficient of performance of about 0.6, the 40 kw of energy supplied by the engine coolant fluid to the generator 24 is sufficient to meet the cooling capacity needs.

The evaporator 24 of the refrigerating absorption unit is connected in a passenger compartment cooling circuit 44 which includes a third heat exchanger 46 for cooling air for distribution in the passenger compartment. The working fluid in the passenger compartment cooling circuit can for example be brine. The absorber 26 and the condenser 28 of the refrigerating absorption unit 20 are incorporated in an absorber/condenser cooling circuit 48 having a fourth heat

exchanger 50. The refrigerant medium can suitably be a mixture of LiBr and water, NH_3 and water or any other sufficient and environmentally neutral medium. Given that 40 kW are used to drive the generator 22 and that the refrigerating absorption unit 20 achieves a cooling power of about 25 kW, the absorber/condenser cooling circuit 48 should be dimensioned to meet cooling demands of about 65 kW.

In a preferred embodiment of the invention, the third heat exchanger 46 is located in an air intake duct 52 upstream of the second heat exchanger 40 of the heating unit 34. Inflow of air exterior of the bus along the air intake duct is regulated by a first airflow control valve 54 positioned in the duct 52 in the vicinity of an air intake 56. Air may be drawn along the air intake duct by means of a fan 58 within the duct. Air within the passenger compartment 14 may be recirculated by means of a branch duct 60 extending from the passenger compartment and linking up to the air intake duct 52. The branch duct 60 may be provided with a flow control valve 62. By suitably regulating the flow control valve 62 and the flow control valve 54 in the vicinity of the opening 56 in the air intake duct 52, a desired proportion of fresh air and recirculated air can be caused to flow across the third heat exchanger 46 and the second heat exchanger 40.

By providing the second heat exchanger 40 and the third heat exchanger 46 in series in the air intake duct 52, the refrigerating absorption unit 20 can be used for drying air which is subsequently reheated by the second heat exchanger 40. This arrangement is particularly advantageous for removing any excess humidity from the passenger compartment caused by introduction of wet passenger clothing, etc.

As is apparent from the drawing, the air intake duct 52 communicates with an air distribution duct network 64 within the passenger compartment 14. The network 64 preferably includes overhead ducts as well as floor-level ducts. in order to ensure adequate demisting of the vehicle windscreen, the air distribution duct network 64 should preferably include a number of nozzles 66 to distribute air across the inside of the windscreen. In a similar manner, nozzles may be arranged to create air curtains at door openings.

The components of the thermal system according to the present invention may be housed on or in the vehicle in a number of advantageous ways. In order to maximize passenger space, it is preferable that at least the first heat exchanger 38 and the fourth heat exchanger 50 are mounted on the roof 68 of the vehicle. Since the first heat exchanger 38 obviates the need for a conventionally located cooling radiator, the space vacated by such a radiator may advantageously be used to accommodate the refrigerating absorption unit 20.

Most preferably, the second heat exchanger 40 and the third heat exchanger 46 are also mounted on the roof. Thus, a roof-mounted unit may be provided which comprises the heat exchangers 46, 40 for cooling and heating the incoming air flowing along the air intake duct 52, the heat exchangers 38, 50 for removing excess heat from the engine cooling fluid and the absorber/condenser cooling circuit 48, as well as the fan 58 and the flow control valve 54 associated with the air intake duct 52.

Control of the thermal system 10 is suitably performed via a central control unit 70.

Naturally, the present invention is not restricted to the embodiments described above and shown in the drawing, but may be varied within the scope of the appended claims. For example, it will be apparent to the skilled person that the first heat exchanger 38 must be capable of dissipating the combined heat energy produced in the engine cooling circuit 18.

CLAIMS:

1. A thermal system (10) for a vehicle (12), particularly a bus, said vehicle comprising a passenger compartment (14) and an internal-combustion engine (16) cooled by an engine cooling fluid flowing through a closed engine cooling circuit (18), said system comprising a refrigerating absorption unit (20) having a generator (22), an evaporator (24), an absorber (26) and a condenser (28), characterized in that said system further comprises:

means for supplying said generator (22) of said refrigerating absorption unit (20) with heat energy from said engine cooling fluid;

means (42) for adding energy to said engine cooling fluid during its passage from said internal-combustion engine (16) to said refrigerating absorption unit (20), and

a first heat exchanger (38) provided downstream of said refrigerating absorption unit (20) for dissipating excess energy in said engine cooling fluid before said engine cooling fluid is returned to said internal-combustion engine (16).

2. The thermal system (10) as claimed in claim 1, characterized in that said means for adding energy to said engine cooling fluid is an exhaust gas heat recovery unit (42).

3. The thermal system (10) as claimed in claim 1 or 2, characterized in that a vehicle heating unit (34) is provided downstream of said refrigerating absorption unit (20) and upstream of said first heat exchanger (38).

4. The thermal system (10) as claimed in claim 3, characterized in that said vehicle heating unit (34) comprises a second heat exchanger (40) for heating air for distribution in said passenger compartment (14).

5. The thermal system (10) as claimed in any one of the preceding claims, characterized in that said evaporator (24) of said refrigerating absorption unit (20) is connected in a passenger compartment cooling circuit (44) comprising a third heat exchanger (46) for cooling air for distribution in said passenger compartment (14).

6. The thermal system (10) as claimed in claims 4 and 5, characterized in that second heat exchanger (40) and said third heat exchanger (46) are placed in series along a common air intake duct (52), said second heat exchanger being placed downstream of said third heat exchanger.

7. The thermal system (10) as claimed in any one of the preceding claims, characterized in that said absorber (26) and said condenser (28) of said refrigerating absorption unit (20) are incorporated in an absorber/condenser cooling circuit (48) having a fourth heat exchanger (50).

8. The thermal system (10) as claimed in claim 7, characterized in that said vehicle has a roof (12) and in that said first and fourth and/or said second and third heat exchangers are mounted on said roof.

9. A method for providing climatic conditions in a passenger compartment (14) of a vehicle (12), preferably a bus, said vehicle comprising an internal-combustion engine (16) cooled by an engine cooling fluid flowing through a closed engine cooling circuit (18), said system comprising

a refrigerating absorption unit (20) having a

generator (22), an evaporator (24), an absorber (26) and a condenser (28), characterized by

supplying said generator (22) of said refrigerating absorption unit with heat energy from said engine cooling fluid;

adding energy to said engine cooling fluid during its passage from said internal-combustion engine (16) to said refrigerating absorption unit (20), and

dissipating excess energy in said engine cooling fluid via a first heat exchanger (38) provided downstream of said refrigerating absorption unit (20) before said engine cooling fluid is returned to said internal-combustion engine (16).

10. The method as claimed in claim 9, characterized by passing said engine cooling fluid through a second heat exchanger (40) for heating air for distribution in said passenger compartment (14), said second heat exchanger being placed upstream of said first heat exchanger (38).

11. The method as claimed in claim 10, characterized by connecting said evaporator (22) of said refrigerating absorption unit (20) in a passenger compartment cooling circuit (44) comprising a third heat exchanger (46) for cooling air for distribution in said passenger compartment (14).

12. The method as claimed in claim 11, characterized by placing said second heat exchanger (40) and said third heat exchanger (46) in series along a common air intake duct (52), said second heat exchanger being placed downstream of said third heat exchanger.

13. The method as claimed in claim 12, characterized by cooling air in said third heat exchanger (46) to a level below a desired temperature for the passenger compartment (14) and heating the thus cooled air in said second heat exchanger (40) to said desired temperature.

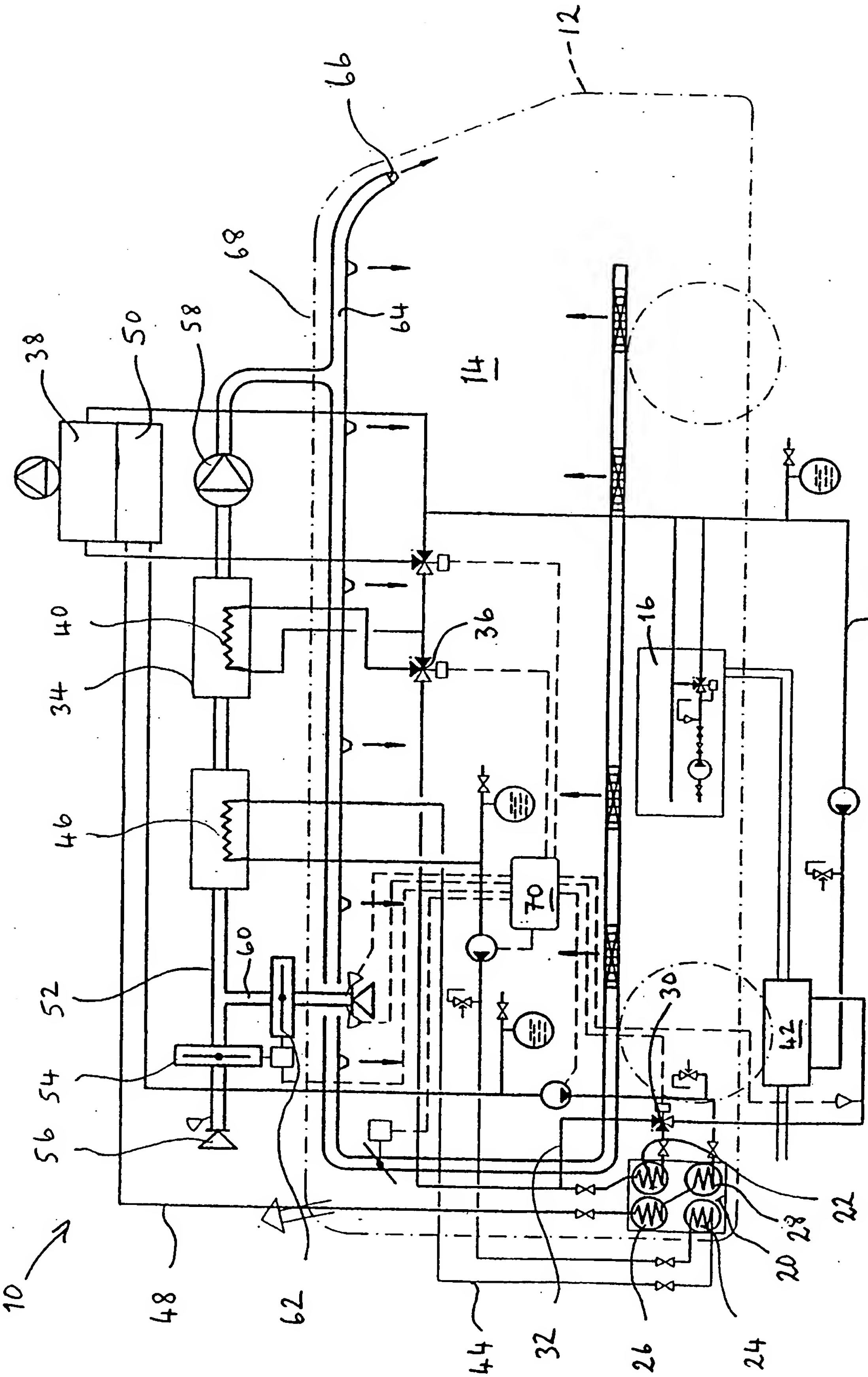
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Fig 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/00209

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B60H 1/32
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B60H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0350764 A1 (SPILLER, PIERANGELO), 17 January 1990 (17.01.90) --	1,9
A	DE 4142314 A1 (INGENIEURBüRO FüR VERSORGUNGSTECHNIK UND ENERGIEBERATUNG DIPL.-ING ERNEST P. SUCKUP), 2 Sept 1993 (02.09.93) --	1,9
A	US 4538424 A (MEYERS), 3 Sept 1985 (03.09.85) -- --------	1,9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 April 1998	20-05-1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Göran Carlström Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/04/98

International application No.
PCT/SE 98/00209

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0350764 A1	17/01/90	AU 4032589 A WO 9000479 A	05/02/90 25/01/90
DE 4142314 A1	02/09/93	NONE	
US 4538424 A	03/09/85	DE 3419284 A JP 60171367 A SE 8404017 A	22/08/85 04/09/85 16/08/85